LINKAGE BASED GROWTH: AN ANALYSIS OF THE DETERMINANTS OF LEONTIEF MULTIPLIER SIZE

An Undergraduate Research Scholars Thesis

by

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ABSTRACT

Linkage Based Growth: An Analysis of the Determinants of Leontief Multiplier Size

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Literature Review

Traditional developmental economics gives primary emphasis to the creation of base industries, such as automobile manufacturing or high-tech sectors. The present research follows Economist Albert Hirschman in emphasizing the size of the linkage from base industries to other sectors of the economy, rather than the size of the base industries themselves. A linkage refers to an interconnection between sectors in an economy. A linkage is like a network, where an increase in inputs from one sector will lead to increases in other "linked" sectors. For example, the production of a car will create demand for steel, thus generating a linkage between the automobile and steel industries.

Growth generated by linkages can be measured using economic multipliers. Multipliers measure how much the initial input is amplified by the linkages that exist within an economy. This study uses multipliers based on the input-output analysis approach developed by Wassily Leontief. An input-output model or Leontief Matrix is used for the analysis of industry interdependence, it allows for the measurement of linkage size. A Leontief matrix consists of three main parts, the transactions between industries, the computation of the final demand per industry, and the value added per industry.

Comprehension of the factors influencing Leontief multipliers, and subsequently, linkage size, is significant because bigger linkages lead to faster economic growth. Based on past research, we know which sectors of the economy yield bigger multipliers (e.g. manufacturing). However, there remains a gap in explaining what makes certain multipliers larger than others. This study will analyze the relationship between multiplier size and four factors: GDP per capita, percentage of GDP in manufacturing, education, and income inequality. We expect to find that a higher percent of GDP in manufacturing will result in bigger linkages, while higher income inequality will result in smaller linkages. GDP per capita and education are used as control variables.

Thesis Statement

We consider percent of GDP in manufacturing and income inequality as possible determinants of multiplier size. Bigger linkages result in greater economic growth; therefore, understanding what factors are correlated with bigger linkages has the potential to positively influence economic policy.

Theoretical Framework

An OLS regression analysis, taking the form of $Y= a + b1*G+b2*M+b3*E+b4*I+e$, will be used to analyze the relationship between multiplier size and the independent variables.

Project Description

Economic multipliers are a measure of how large or small the linkages of an economy are. The size of a linkage is important because bigger linkages mean one sector's growth can cause growth in other sectors of the value chain. This study has two purposes: 1) to identify why multipliers are significant by examining key factors that could lead to bigger rather than smaller linkages. 2) To examine whether income inequality and changes on the manufacturing sectors have an influence on multipliers.

We consider percent of GDP in manufacturing and income inequality as possible determinants of multiplier size because: A) Countries with a greater share of output in manufacturing will often have fewer imports. This is because their manufacturing sector is enough to supply for their own industrial demand. Moreover, manufacturing has higher multipliers than other sectors in the economy. (Cohn et. al 2019) B) Income inequality decreases the ability of households to make consumer goods purchases, thus decreasing the wage multiplier effect. Additionally, income inequality leads to what social scientists call "disarticulated growth," which results in slower economic growth and greater inequality.

We use GDP per capita and education as control variables. Countries with a higher GDP per capita usually have higher wages than poorer countries, thus resulting in a bigger demand for consumer goods. More educated people are paid higher wages, leading to a more significant demand for consumer goods. Further, countries with higher levels of education are associated with greater technological advances, and thus a more robust industrial sector.

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KEY WORDS

Type I Multiplier	Economic multiplier from industrial purchases (also "Industrial Supplies Multiplier" or "Industrial Multiplier")
Type II Multiplier	Multiplier from both industrial purchases and worker and consumer expenditures (also "Total Multiplier")
Type II-I Multiplier	Multiplier from worker and consumer expenditures, found from the difference between the Type II and Type I multiplier (also "Worker and Consumer Expenditure Multiplier" or "Wage Multiplier")

INTRODUCTION

The traditional focus by development sociologists on transformative sectors assumes that once a transformative base sector is successfully implanted, the rest of the economy will develop on its own. The present research focuses less on base industries and more on multipliers. Multipliers are the additional economic growth that occur as a result of an increase in activity in a basic industry. The traditional focus on transformative base sectors implicitly assumes that the multipliers in all societies are the same – and that every society will grow to the same degree once a basic industry is successful. Based on prior research, we argue against this assumption and acknowledge the difference in sectoral multiplier size. (Cohn et al 2019)

The two most important forms of multipliers are purchases by one base industry of supplies from other industries, Type I multipliers; and consumer purchases made by workers with salaries earned in a base industry, Type II-I multipliers. In this analysis, we will be distinguishing the multipliers of consumption expenditures (Type II-I) with those of industrial supply purchases (Type I). Multipliers received some analysis in the work of Hirschman (1969) who argued for the importance of forward and backward linkages as motors of development. However, the fullest approach to this issue, and the one we follow here, is that of Wassily Leontief. (1951, 1986, Miller and Blair 2009)

Hundreds of input-output tables have been calculated. However, surprisingly, very little research reports the actual size of Leontief multipliers. In particular, the multipliers for households and for manufacturing are almost never reported. Traditionally, Leontief tables are used as an analytic tool for simulation and social forecasting. For example, an investigator might inquire what the effect of doubling investment on a particular sector of the economy would be on economic growth and use a Leontief table to generate his or her predictions. This research is novel by emphasizing the size of individual coefficients and not the predictive properties of the multiplier coefficients.

Input-output tables, also called Leontief matrices, summarize all the transactions between businesses, households, government, and the foreign sector in an economy that occur in a year. The conceptual basis of input-output analysis, along with the methodology by which multipliers are calculated, can be found in any textbook on input-output analysis. The treatment here follows Miller and Blair's 2009 *Input-Output Analysis: Foundations and Extensions.*

This research emphasizes two different theoretical perspectives of economic growth. One is that of social democratic development, which argues that transferring resources to the poor will create economic growth. The idea of social democratic development is that social equality can increase rates of economic growth by increasing the demand for consumer goods. (Korpi 1985, Myrdal 1970, Moene 2016, Lansley 2012) The other perspective is import substitution, first introduced by Friedrich List as the *infant industry argument* and Latin American dependency theorists. (Szirmai 2015) This strategy calls for local industry protection in the form of restriction of imports and promotion of local manufacturing. From the *dependista* perspective, protecting local industries from foreign competition is key for national development.

CHAPTER I

HOW ARE MULTIPLIERS CALCULATED?

Leontief matrices consist of three main sections: 1) intermediate transactions between industries, 2) final demand per industry, and 3) value added per industry, all for a given year period, as seen in Table 1.

Table 1. Input-Output table for multiplier calculations.

INDUSTRIES		PRODUCERS AS CONSUMERS				FINAL DEMAND	
		Industry 1	Industry 2	…	Industry n	Household Consumption	Other Final Demand*
PRODUCERS	Industry 1	Millions USD	Millions USD	…	Millions USD	Millions USD	Millions USD
	Industry 2	…	…	…	…	…	…
	…	…	…	…	…	…	…
	Industry n	Millions USD	Millions USD	…	Millions USD	Millions USD	Millions USD
VALUE ADDED	Employee Compensation	Millions USD	…	…	…	GROSS DOMESTIC PRODUCT	
	Other Value Added**	Millions USD	…	…	…		

*Other final demand categories vary by table, but often include government purchases and net exports.
**Other value-added categories may include taxes on production and consumption of fixed capital.

Each of these sections may have a varying level of detail, for example, having general industries such as “Manufacturing,” or very specific ones, such as “Manufacture of Paper Products.” Aggregation from more specific to more general industry classifications is possible to allow for comparison between tables with different detail levels.

We are interested in these tables because they allow us to calculate two types of “multipliers” for each industry, which represent the total increase in the economy’s output due to a unit increase in the final demand for the industry’s production. The reason there are these “spillover effects,” or extra growth, is because of how industries are connected. An increase in the production of any product will lead to an increase in demand for all the inputs (goods, services, and labor) employed in the production process. When workers use their income to generate more final demand, the cycle starts over again, leading to more increases in output all the way down the supply chain.

These multipliers can be computed in two ways: 1) by treating households as part of exogenous final demand, and 2) by endogenizing households, treating them as an industry, with labor (measured by compensation to employees) as their output which is consumed by other industries. The multipliers calculated by the former method are called Type I multipliers or Industrial Supplies multipliers, as they depend only on the additional purchases made by businesses, not by households. Type II multipliers, also called Total multipliers, are calculated using the latter method and capture the additional production that occurs when workers make purchases with their new income.

In our analysis we also calculate what we call the Worker and Consumer Expenditures multiplier, which is the difference between the Type II and Type I multiplier, providing a measure of the extra growth attributable to feeding worker compensation back into the economy as household consumption.

The calculation of input-output multipliers with n industries begins with the calculation of a nxn matrix of "technical" or "input-output" coefficients, A, which represents the economy's supply chain relationships at the point in time the input-output table was constructed. The technical coefficient a_{ij} is the proportion of industry j's total output x_j that is consumed by industry i as part of its production process. Total output refers to an industry's total production, regardless of whether it is sold for intermediate or final use. As explained above, the level of total output x_j depends not only on the final demand for sector j's products, but also on the production levels of all other industries that are part of its supply chain.

This leads to the equation,

(1) $X = AX + F$,

where total output X is the sum of intermediate consumption AX and final demand F. In an n-industry economy, X and F are nx1 vectors, and A is the aforementioned nxn matrix of technical coefficients.

As we are interested in the effects of changes in final demand on changes in total output, we can rearrange the above equation into the form

(2) $X = (I-A)-1\ F$,

more commonly seen as

(3) $X = L\ F$, where

(4) $L =(I-A)-1$

is the nxn Leontief inverse matrix.

To calculate the multiplier for the jth industry in an input output table, find the change in total output, ΔX, when the change in final demand, ΔF, is one for the jth industry, and zero for all other industries. For example, the multiplier for industry 1 is calculated as follows:

(5) $m_1 = \begin{bmatrix} l_{11} & l_{1n} \\ & \ddots & \\ l_{n1} & l_{nn} \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} = \sum_{i=1}^{n} l_{i1}.$

So, generally, the multiplier for industry j is the sum of all entries in column j of the Leontief inverse, as this represents the total increase in output in each industry when the final demand for industry j's products is increased by one unit, all else equal.

CHAPTER II

INCOME INEQUALITY AND LOCAL MANUFACTURING

Income Inequality

One of the great challenges in the Sociology of Development has been to identify successful strategies of humanistic egalitarian development that both increase GDP and improve the standards of living of poor people. For most neoclassical economists, increasing GDP in and of itself should be enough to significantly reduce poverty. They could take support in this from the work of Firebaugh and Beck (1994), which shows GDP to be a powerful correlate with measures of economic well-being. For most other sociologists, however, this is not enough.

Levels of inequality are extremely high in the Global South, and they are rapidly increasing in both the Global North and the Global South. (Dabla-Norris et al 2015, Stiglitz 2013) Dependency theorists have long argued that high levels of social inequality can lead to *disarticulated development* in which indicators of economic activity such as GDP, increase without a commensurate increase in standards of living for the general population. (Amin 1976, Stokes and Anderson 1990) Furthermore, the expansion of capitalism, particularly in the age of globalization, has led to substantial proletarianization and the concrete worsening of economic prospects for a number of vulnerable populations. (Robinson 2010, Sassen 2011) This has led many sociologists to give primacy to social inequality and social redistribution rather than growth per se. (Heller 1999, Therborn 2014)

Local Manufacturing

Following the dependency theorists' strategy of economic growth known as "import-substitution," we included as a key part of our research a measure of the levels of local manufacturing capacity. The idea of import-substitution has its origins in Friedrich List who was the first promoter of the "infant industry argument," which called for tariff protection of German industries against British penetration. (Szirmai 2015) The logic is that if local industry is not strong enough, then foreign competition is going to drive local industries out of business. Dependency theorists support the stance of Elsenhans (1996), who stresses the importance of a strong domestic market as a safe path to sustained economic growth. Domestic economies are strengthened by rising wages, and thorough local industry protection. Core countries have all strong local economies, while low wages and weak domestic markets characterize the periphery. (Elsenhans 1996)

Imported manufactured goods (i.e., machinery) are used as capital for primary product exports (i.e., agriculture and mining) in developing countries. The problem comes from the lack of linkages within the economy. This lack of linkages comes from the fact that imports are purchases made abroad, and therefore, they have no connection to the local economy. If a country does not have enough manufacturing capacity, then it will be forced to increase its imports to supply the needs of the local industries. These imports will, in turn, reduce the purchases that industries make from other industries within the same country. Reducing inter-industry purchases will, theoretically, reduce the size of the linkages and subsequently the multiplier effects.

CHAPTER III

METHODOLOGY

This study utilized the OECD Input-Output Database as the primary data source for Input-Output tables. (OECD 2018) The OECD Input-Output Database is a compilation of Leontief matrices for OECD countries and selected non-member economies. All of the OECD matrices are constructed using standard conventions, we utilize the matrices that are standardized by the International Standard Industrial Classification (ISIC) Rev. 4.

In our sample we exclude countries that utilize non-standard methodologies in matrix construction or have missing data. For purposes of Type II multiplier calculation, only matrices that contain a row for wages, labeled as compensation of employees, and a column for household, labeled as private consumption, are used. The years 2005 and 2015 have the largest number of usable Leontief matrices, and are therefore our sample time periods. Our final sample is comprised of 55 middle to upper income countries. The calculation of Leontief matrices requires large amounts of high-quality national economic data. Low income countries generally don’t have the state capacity to produce high quality national statistics. (Jerven 2013, Morgenstern 1965) As a result, few usable Leontief matrices exist for low income countries, as they’re either not available or excluded due to the probability of unreliable estimates. Nevertheless, analyses of data limited to middle to high income countries remain useful in determining growth. Debates about the contradictions or lack of same between redistribution and growth are particularly salient in these settings.

The matrices utilized in this study contain up to 36 different industry classifications. We standardize the industries by aggregating them into 11 categories: Agriculture-Forestry-Fishing;

Mining-Quarrying; Manufacturing; Electricity-Water; Construction; Wholesale-Retail Trade; Transport-Storage-Communication; Finance; Government; Other Services; and Households. The Industrial Supplies multiplier, Type I multiplier, calculation does not include the Household industry. Whereas, the Type II multiplier calculation, as the Total multipliers, does include the Household industry. Type I and Type II multipliers are calculated for each of our sample countries' standardized industries, for the years 2005 and 2015. The difference between the Type II and Type I multipliers are found to identify the Type II-I multiplier, Worker and Consumer Expenditures multiplier, for each countries' standardized industries. The ten Type I, eleven Type II, and ten Type II-I multipliers for each country were averaged to establish one Type I multiplier, one Type II multiplier, and one Type II-I multiplier for each country, for 2005 and 2015. Table 2 shows an example of the multiplier calculation process for a country, for a specified year.

Table 2. Multiplier calculations.

Country	Type	Industry 1	...	Industry 10	Household Industry	Multiplier Average
Country A	Type I	Value	…	Value	(blank)	=AVG(Industry1:Industry10)
Country A	Type II	Value	…	Value	Value	=AVG(Industry1:Household)
Country A	Type II-I	Value	…	Value	(blank)	=AVG(Industry1:Industry10)

Note: (…) indicate continuity.

Variables

The established Type I and Type II-I multipliers, four for each country (two for 2005 and two for 2015), are the dependent variables in our analyses. Type I multipliers or Industrial Supplies multipliers refer to the effects of an expansion of industry via increased purchases made by businesses, not households. The Type II-I multipliers or Wage multipliers refer to the effects of an expansion of industry in increasing GDP via increased purchases of consumption goods by workers in an industry.

The two independent variables are:

a) **Manufacturing as a Percentage of GDP**.

b) **Income Inequality.**

We utilize the GINI index data from the World Bank for our income inequality variable. (World Bank 2019a) The data of the value added by manufacturing as a share of GDP (2010 USD), from the World Bank, is our percent GDP in manufacturing variable. (World Bank 2019b)

We include as controls:

a) **GDP Per Capita**. Richer countries are likely to have higher multipliers overall – since both their companies and their workers are wealthier than those in poor countries. Larger budgets mean more purchases.

b) **Educational Attainment.** Higher levels of educational attainment tend to equate to higher wages; moreover, education can be a measure of a nation's ability to generate its own upper-tier products.

A dataset of the mean years of total schooling across all education levels, for the population aged 25+, is our education variable. (Lee-Lee 2016; Barro-Lee 2018; UNDP HDR

2018) While GDP per capita data, in current USD, is used from the World Bank. (World Bank 2019c)

OLS regression analyses are used to analyze the relationship between multiplier size and the independent variables. This model takes the form of

(6) $Y= a + b1*G + b2*M + b3*E + b4*I + e$,

where "*Y*" is our dependent variable (multiplier size). The letter *G* stands for GDP; *M* for percentage of GDP in manufacturing; *E* for education; and *I* for income inequality. In the equation, "*a*" is an intercept term, $b_{1\text{-}4}$ are constant scalars, and "*e*" is an error term. We used this equation and model to estimate the relationship between multiplier size and the independent variables (two determinants and two controls).

CHAPTER IV

RESULTS

Table 3. OLS estimates of the effect of selected variables on industrial (Type I) multipliers.

	2005				2015			
Variable	Coef.	SE	P-value	R^2	Coef.	SE	P-value	R^2
GINI only	-.108	.002	.011	.012	-.131	.003	.002	.017
% GDP in Manuf. only	.086	.003	.043	.007	.020	.003	.648	.000
All Variables				.196				.061
GINI	-.147	.003	.016		-.092	.004	.110	
% GDP in manuf.	.120	.004	.010		.069	.003	.115	
GDP	.044	.000	.457		.276	.000	.000	
Education	-.057	.011	.346		-.160	.015	.009	

Note: $N = 55$.

Table 3 shows the results from the analysis of the Type I multipliers and the independent variables. The first two equations are bivariate regressions of the effects of GINI coefficients and Percent GDP in Manufacturing on Industrial multipliers (Type I). As expected, income inequality (GINI coefficients) have a negative relationship with the Industrial multiplier. These findings are highly statistically significant. The findings are confirmed independently for both the 2005 and the 2015 panels. Percent GDP in Manufacturing appears to coincide with increased Industrial multipliers; however, it has a very weak positive relationship. Moreover, these findings are significant for 2005, but highly insignificant for 2015. This suggests there are other variables that affect the size of Industrial multipliers, beyond the two variables we have analyzed. The explained variance of all four equations are low.

In the bivariate regression model with control variables, labeled “All Variables,” both the inequality variable (GINI) and percent GDP in manufacturing continue to be in the correct direction; however, while both are significant in 2005, they are both insignificant in 2015 - significant only at the alpha .12 level. The performance of the control variables is nonuniform and mixed. The relationship between Industrial multipliers and both GDP and educational attainment is highly insignificant in 2005, but highly significant in 2015 - at less than the alpha .01 level. GDP per capita performs in the expected direction, with higher multipliers being associated with richer countries. Educational attainment, however, has a troublesome, negative relationship with the Industrial multiplier.

Table 4. OLS estimates of the effect of selected variables on wage (TYPE 2-1) multipliers.

	2005				2015			
Variable	Coef.	SE	P-value	R^2	Coef.	SE	P-value	R^2
GINI only	-.367	.004	.000	.134	-.230	.005	.000	.053
% GDP in Manuf. only	-.251	.006	.000	.063	-.227	.006	.000	.051
All Variables				.179				.129
GINI	-.198	.005	.000		-.165	.007	.003	
% GDP in manuf.	-.128	.007	.003		-.179	.006	.000	
GDP	.092	.000	.086		.213	.000	.000	
Education	.122	.021	.028		-.074	.028	.207	

Note: *N* = 55.

Table 4 shows the results from the analysis of the Type II-I multipliers and the independent variables. The first two equations are bivariate regressions of the effects of GINI coefficients and Percent GDP in Manufacturing on Wage multipliers (Type II-I). As expected, income inequality (GINI coefficients) is correlated with a reduction in Wage multiplier size – statistically significant at the alpha .000 level. However, unexpectedly, Percent GDP in Manufacturing also lowers Wage multipliers. These findings are highly statistically significant. The findings are confirmed independently for both the 2005 and the 2015 panels. The explained variance of all four equations are low. Our predictions about inequality were confirmed, but our assumption that a higher percent of GDP in manufacturing would result in bigger linkages, is not.

The results of the bivariate equations are re-confirmed in the models with control variables. The inequality variable (GINI) continues to be in the correct direction with findings that are significant at less than the alpha .01 level. This applies to all years. Meanwhile, percent GDP in manufacturing continues to be in an unexpectedly, negative direction, with findings that are significant at less than the alpha .01 level. This applies for all years. We suspect this odd result stems from there being missing variables in the model which affect the size of Wage multipliers.

The performance of the control variables with Wage multipliers continues to be nonuniform and mixed – as seen with Industrial multipliers. GDP performs as expected, rich countries have consistently higher multipliers than poorer countries; although, the findings for 2005 are less significant and strong than the findings for 2015. The performance of educational attainment is mixed. The relationship between education and Wage multipliers is positively correlated and significant, as expected, in 2005. However, in 2015, the relationship turns perverse and is negative, but insignificant at less than the alpha .05 level.

CONCLUSION

Overall, the findings confirm that inequality is an economic determinant, and provide support for the theories that claim equality helps promote development. Our analyses demonstrate that income inequality is negatively associated with Wage multipliers, meaning that as income equality increases, Wage multipliers decrease. Based on Keynesian economics, the poor have a higher propensity to consume than to the rich. Therefore, income that is accredited to the poorer population is reinvested into the economy in the form of consumer good purchases. The increased consumption results in further economic growth. These findings imply that economic policies which reduce income inequality will increase the Wage multiplier, and thus positively affect economic growth.

This implication demonstrates the important role Leontief input-output multipliers can play in informing sociology of development studies as well as economic policies. Past research has primarily focused on transformative base sectors, such as automobile manufacturing, as the drivers of economic growth, without consideration for their linkage to other sectors and negating concerns of disarticulation and distribution. Inter-industry linkages have profound effects on the distribution of the benefits and losses from the development process, while increases in GDP does not identify who benefits from increases in the key industries and how this impacts everyone else in the economy as a whole. Current economic policies could be better informed if inter-industry linkages and an understanding of income inequalities' perverse effect on economic growth were taken into consideration.

Our findings did not confirm percent GDP in manufacturing as having a significant, positive effect on Wage or Industrial multipliers. This finding, along with the lack of strong evidence for income inequality's effect on Industrial multipliers, suggests the possibility of alternative determinant variables of multiplier size. A lack of conclusive findings for the relationship between percent GDP in manufacturing and Industrial multipliers, implies that a countries' import levels and industrial composition should be explored as possible determinants. Moreover, there are notably some economies with extremely hypertrophied service sectors and very high multipliers overall. The dynamics of these super-developed service sectors and how these relate to the dynamics of local manufacturing should be explored.

Finally, we would like to conclude by clarifying that the results from this analysis are just a piece of evidence pointing in one direction. It would be irresponsible from us to imply causality from our results. Viewing the relationships suggested in this research from multiple points of view is strongly encouraged in order to make stronger conclusions. Following the recommendations of Babones (2014), a system of different models should be used to provide a bigger and clearer picture of the results of this study.

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